Space Weather Technical Forecast

Issued on Monday, 25 March 2024 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further Minor/Moderate radio blackouts (R1/R2) expected. Current S1 conditions slowly reducing. Minor to Moderate geomagnetic storms (G1-G2) probable for next 12 to 18 hours given CME arrival 24th Mar and ongoing HSS, with a chance of Strong geomagnetic storm (G3) interval at first.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 and 18 was Moderate, with AR3615 producing occasional M-class flares through the period with the largest being an impulsive M4.4 flare at 25/0614UTC. Eight active regions cover the visible disc. AR3615 is the largest and most complex group (Fkc/Beta-Gamma-Delta) with recent minor reorganisation of the central spots in recent hours. Changes in other groups were minor by comparison. A small, biplolar, unnumbered region lies to the southwest of AR3615.
No significant Earth-directed Coronal Mass Ejections (CMEs) observed on available coronagraph imagery over the last 24hr.

Solar Wind / Geomagnetic Activity: The solar wind at L1 measured by ACE and DSCOVR were initially at elevated levels (500-550km/s). A complex CME associated with the X1.1 flare on the 23rd March, which may have been two CMEs associated with the same event, then arrived at L1 at 24/1410UTC and solar winds jumped to strong-very strong speeds (750-850 km/s) where they have remained since. The solar wind density has largely been around or just above average. The IMF was moderate but jumped to strong values from the CME arrival, briefly touching very strong (~33nT at 25/1606UTC). Bz initially weakly fluctuated -6/+6nT but became strongly negative from CME impact until 25/1548UTC, peaking at -26nT around 25/1510UTC from which point it has largely been strongly positive, especially since entering the magnetic cloud. The phi angle showed a significant degree of variability and was largely negative (towards the Sun) but turned positive (Away from the sun) on entering the magnetic cloud, until around 25/0600UTC.

The net result of the above solar wind measures was initially Active geomagnetic (Kp4). However from 24/1200UTC conditions became moderate geomagnetic storm (Kp6) following the CME arrival, peaking at severe geomagnetic storm (Kp8) from 24/1500UTC, falling to a strong storm (Kp7) at 24/1800UTC and has since been mostly Active to G1 (Kp4-5) from 24/2100UTC.

Energetic Particles / Solar Radiation: Solar radiation was at S1 levels and have been on a slow and steady decline.
High energy electron flux (greater than 2MeV) observed at GOES16 was at Normal Background levels. The observed 24-hour fluence was below the Active threshold, with a value at 25/0001UTC of 1.63e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is expected, with further M-class flares expected from primarily the highly active AR3615 through the forecast period, with a chance of isolated X-class flares.

UK Aurora Forecast: Conditions could remain unsettled into Monday night following yesterday's CME

Solar Wind / Geomagnetic Activity: A CME associated with the X1.1 flare on the 23rd March arrived at L1 at 24/1410UTC. Combined with a HSS associated with CH12/- is currently giving very strong solar wind speeds. There are no other Earth directed CMEs in the forecast.
Solar winds starting at strong levels with a slow and steady decline over the coming days. Solar winds are expected to reduce towards slightly elevated by Day 4 (28 Mar).
Initially geomagnetic activity starting at Active (Kp4) levels with further G1-G2, minor to moderate storm conditions probable and a chance of G3, strong geomagnetic storm for the next 12 to 18 hours. By day 2 and 3 (26 and 27 Mar) the risk of G1-G2 conditions reduces with a a return to generally Quiet to unsettled (Kp2-3) conditions probable by the end of the period in the absence of any further CME enhancements.

Energetic Particles / Solar Radiation: High energy proton flux, as observed by GOES18 is now at S1 levels. The decline is expected to continue and probably falling back to background levels by day 2 (26 Mar), although confidence is reasonably low given the number of different factors as well as the dominant sunspot group (AR3615) making continued progress westward through this four-day period to gradually increase the risk of further enhancement in association with significant flaring.
High energy electron flux (greater than 2MeV) starting at background levels at first, given the ongoing geomagnetic conditions associated with the HSS and recent CME impact. Activity will increase given the solar winds enhancement in coming days with a sharp increase likely, but probably not reaching the levels as the current Met Office REFM guidance suggests. The associated 24-hour fluence is below Active threshold initially, but with an increasing likelihood of reaching Active fluence through the guidance period.

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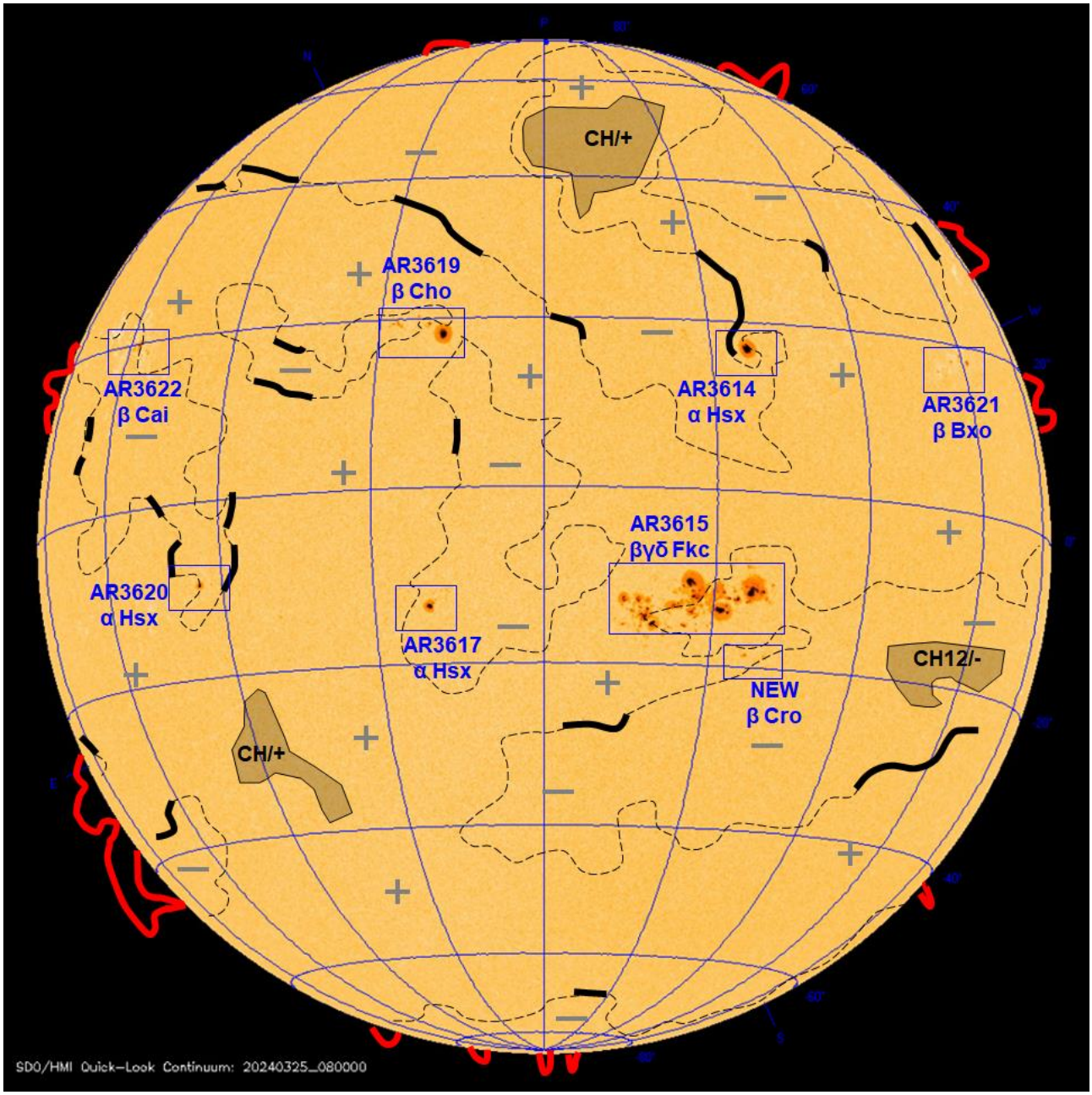
Figure 1. Solar Analysis Valid 0800UTC, 25 March 2024.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME associated with the X1.1 flare from a broad region north of AR3614 on the 23rd March, produced a complex halo CME which arrived at L1 at 24/1410UTC. The arrival of this CME combined with a HSS associated with CH12/- in the southeast of the disc is currently giving strong solar wind speeds of around 750 km/s. There are no other Earth-directed CME's in the forecast.

Solar winds at strong levels will probably decline erratically over coming days as the impacts from the CME begin to wane. However due to MOSWOC ENLIL guidance historically predicting solar winds associated with CH12/- poorly, there is some uncertainty regarding the reduction of the solar wind over the coming days. However they will probably reduce towards background levels by Day 4 (28 Mar) in the absence of any further enhancements.

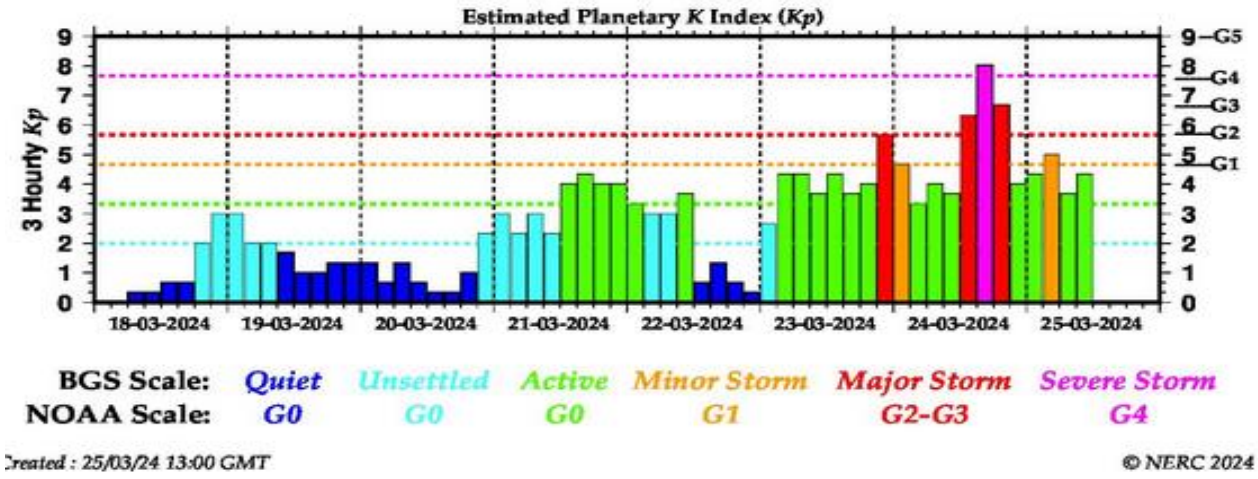
Geomagnetic activity at Active (Kp4) levels currently with further G1-G2, minor to moderate storm conditions probable and a chance of G3, strong geomagnetic storm for the next 12 to 18 hours. By day 2 and 3 (26 and 27 Mar) the risk of G1-G2 conditions reduces with a a return to generally Quiet to unsettled (Kp2-3) conditions probable by the end of the period in the absence of any further CME enhancements.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	60	40	20
Strong	G3	Yes	20	20	10	1
Severe	G4	Yes	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: Latest plot of BGS geomagnetic activity over past week.



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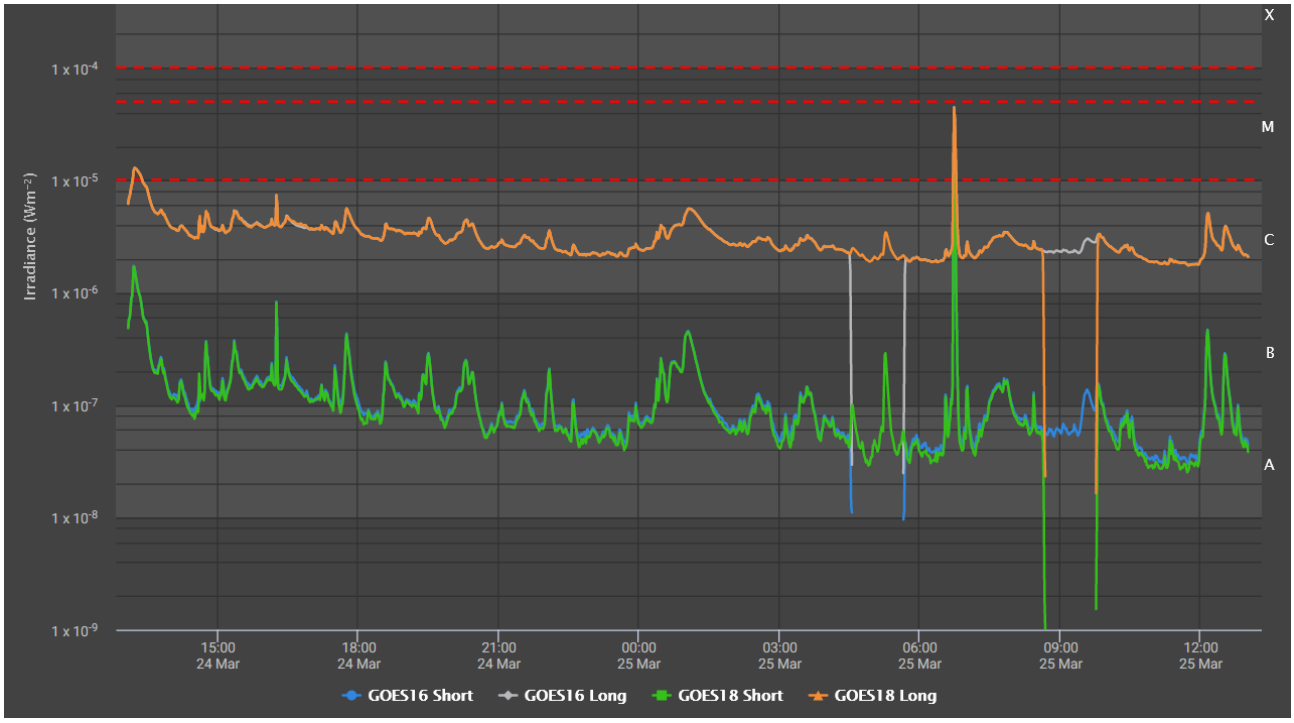
Radio Blackouts - X-Ray Flares:
The current Earth-facing disc is dominated by AR3615, with occasional M-class flares through the period. This region continues to comprises a large number of spots although limited areal growth seems to be resulting in some consolidation. Significant mixing of its constituent magnetic polarities remains evident, and the displays a Mt Wilson Beta-Gamma-Delta configuration. The X1.1 flare on the 23rd was primarily associated with AR3614, which remains generally stable and much more magnetically simple, though it lies within a large plage region. AR3615 (and AR3614) are expected to remain on the visible disk throughout much of this guidance period. No significant new sunspot regions are currently signalled to return onto the disk. M-class flare activity is expected through the period, primarily from AR3615. There is also a chance of isolated X-class activity from this region, although for now regular energy discharge perhaps seems to be mitigating that risk somewhat.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	70	70
Very Active	R3 to R5 X Class	No	30	20	30	20

Figure 3: Latest plot of X-ray flux at GEO with some M-class flares over past 24 hours.



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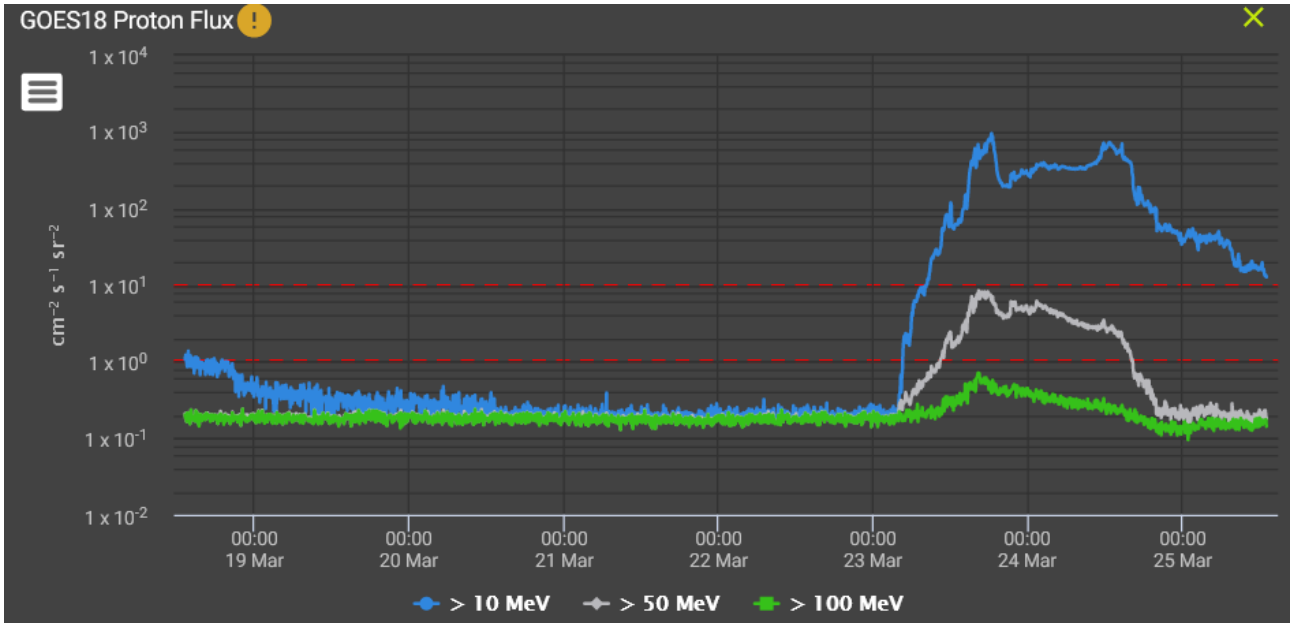
Solar Radiation Storms - (High Energy Protons):
High energy proton flux, as observed by GOES18 has recently reduced from S2 levels to S1 levels. A slow decline is now expected through Day 1 (25 Mar) in the absence of further significant flare activity, perhaps falling back to background levels by later day 2 into day 3 (26-27 Mar), although confidence is reasonably low given the number of different factors as well as the dominant AR3615 making continued progress westward through this four-day period to gradually increase the risk of further enhancement in association with significant flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	Yes	100	70	40	30
Very Active	≥ S3 *	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton flux at GEO with data from GOES 18 satellite showing current storm conditions.



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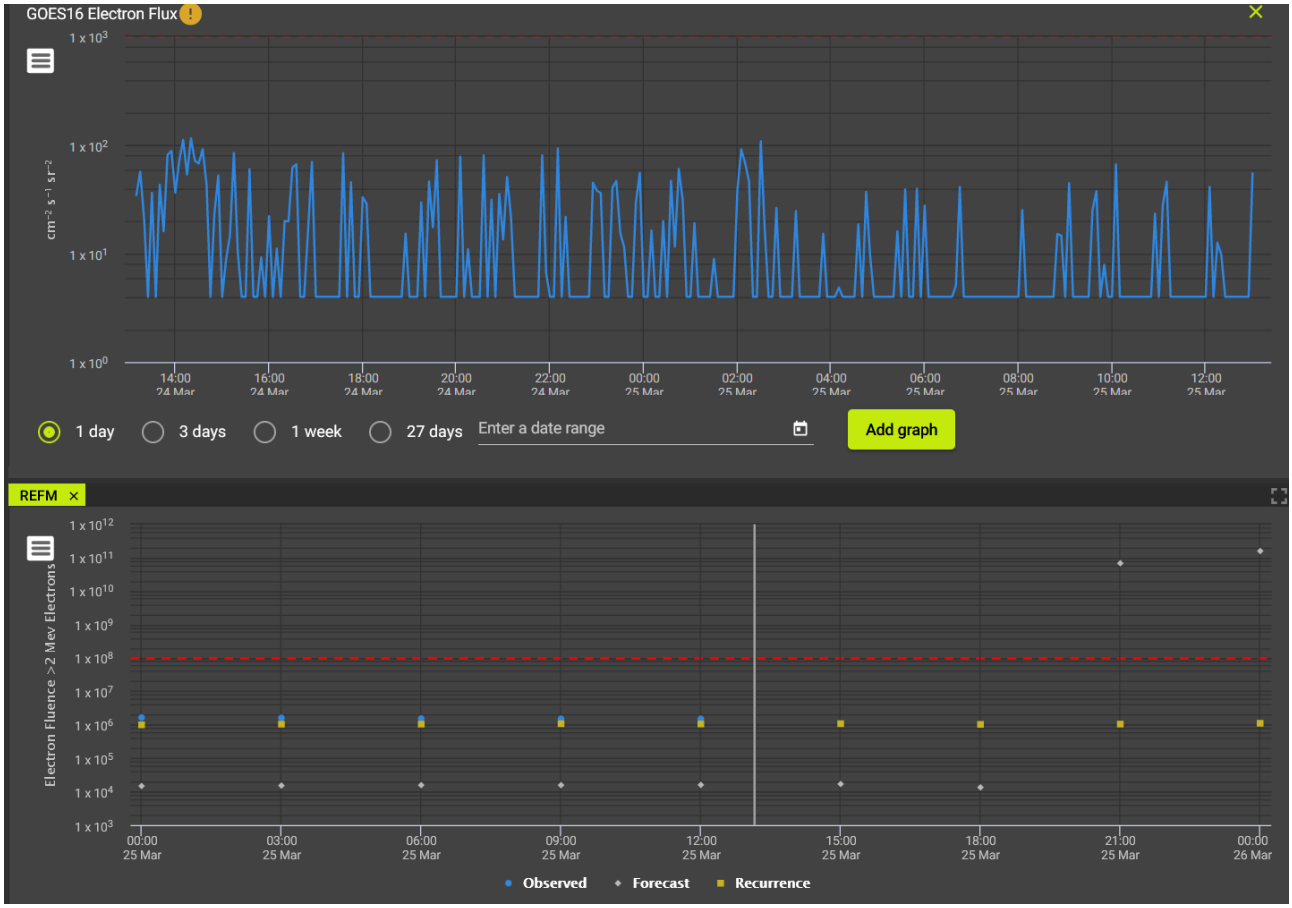
High Energy Electrons Event (≥ 2MeV):
GOES16 high energy electron flux iat background levels initially given the ongoing geomagnetic response associated with the current connection to the HSS of CH12/- and recent strong CME arrival. As associated geomagnetic activity eases over the next few days, the electron flux at GEO is expected to rise to Moderate or High levels through the period.
The associated 24-hour fluence is below the Active threshold. Fluence is expected to rise sharply in the coming days with active fluence becoming increasingly likely. MOSWOC REFM guidance showing increasing fluence over the next few days is accepted, although it is unlikely to reach the magnitudes currently indicated.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	20	40	50	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	5	5	5

Figure 5: High energy electron flux at GEO at Met Office REFM guidance in coming days with likely over-forecast for fluence levels.



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